Nonlinear Waves at Comets and in the Interplanetary Space

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Spacecraft observations at comet P/Giacobini-Zinner, comet P/Halley and at cornet P/Grigg-Skjellerup indicate the presence of large amplitude low-frequency electromagnetic waves (frequencies ~ 0.01– 0.05 Hz) produced by plasma instabilities driven by the pickup ion distributions. Although there are several differences and peculiarities associated with each comet, the following broad picture has emerged. Far from the cornets, the wave amplitude is small and it increases as the comet is approached. At comet P/Halley the wave fields are characterized by irregular waveforms with predominantly linear polarization and with considerable wave energy at frequencies above the local water group ion gyrofrequency. The typical wave amplitude arc found to be $\delta|\mathbf{B}|/B_0 = 0.1$ for the magnitude variations and $|\delta\mathbf{B}|/B_0 = 0.5$ for the vector variations. At comet P/Giacobini-Zinner the wave fluctuations have mixture of linear and elliptical (primarily a right-hand mode) polarizations and their intensities were considerably higher than those at comet P/Halley. Not only were the wave intensities greater, but the wave forms were highly steepened. The peak-to peak wave amplitudes were $\delta|\mathbf{B}|/B_0 = 0.5$ and $|\delta\mathbf{B}|/B_0 = 2.0$. On the other hand, near comet P/Grigg–Skjellerup very regular wave fields with almost exclusively left-hand polarization in the spacecraft frame are observed just outside the bow wave. Typical peak-to- peak numbers for comet P/Grigg–Skjellerup were found to be $\delta|\mathbf{B}|/B_0 = 0.1$ ant] $|\delta\mathbf{B}|/B_0 = 0.3$. We briefly review observations of the nonlinear waves at comets P/Giacobini-Zinner and P/Grigg-Skjellerup and also present new results which could possibly explain the detailed characteristics of the "linear polarization" of the large amplitude waves at comet P/Halley.

In the interplanerary medium, high-speed streams are characterized by the presence Of non-linear Alfvén waves with peak-to-peak transverse fluctuations as large as $|\delta\mathbf{B}|/B_0$ of 1 to 2. These nonlinear Alfvén waves are often phase-steepened, with rotational discontinuities (RDs) bounding the edges, and the slowly rotating Alfvén wave portion plus the fast rotating discontinuity comprise 360° in phase rotation. These waves and RDs arc shown to be phase-steepcrled, spherical, arc-polarized waves. The propagation direction and the jump conditions across these Alfvén shocks wil be discussed.